

Identification of Cardiovascular Mortality Risk in Patients with Respiratory Disease

Cardiovascular Mortality Risk in Respiratory Disease

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Abstract— Circulatory and respiratory diseases are the leading cause of death. Recent studies suggest that respiratory diseases can increase the risk of cardiovascular disease, yet the reason is unknown. In this study, an artificial neural network model is built to predict the possibility of death due to cardiovascular disease with given respiratory conditions. Data shows that cardiovascular disease was an underlying cause for approximately 16.8 percent of the patients suffering from respiratory diseases. Chronic lower respiratory disease has the highest number of deaths, with 72,125 cases. Further studies are needed to find the exact symptoms causing death due to an underlying cause of cardiovascular diseases with respiratory diseases as one of its multiple conditions.

Keywords—Artificial neural networks; machine learning; mortality;

I. INTRODUCTION

Cardiovascular disease (CVD) has become one of the most unforeseen problems in the world, accounting for the morbidity and mortality associated with it [1]. CVD tends to be more critical when patients suffer from respiratory diseases [2]. Respiratory diseases are one of the leading causes of death, and few studies have addressed that they can increase the risk of CVD [3]. Although respiratory diseases can cause CVD, the effect of the underlying risk of CVD on the incidence of respiratory diseases is unknown [4]. The current study aimed to predict the possibility of death due to CVD for patients suffering from respiratory diseases using artificial neural networks.

II. METHODS

A total of $N=3,390,278$ with 121 features were taken from the Centers for Disease Control and Prediction (CDC) website for the year 2020 [5]. In the given data, the underlying cause (cause of death) and multiple patient conditions are given in the ICD-10 2016 coded format, and data was decoded to a general format. From the decoded data, the number of patients suffering from respiratory diseases and dying due to the underlying cause of CVD was studied. Circulatory and respiratory diseases are further classified into their subparts and studied. Data were divided into 80% training set and 20% of the testing set. The training set was further divided into a validation set of 30% and a training set of 70%.

An artificial neural network (ANN) consisting of an input layer of 16 neurons, 4 layers with neurons 16, 8, 4, and 2 are used with activation function of relu, and an output layer with a single neuron was built with a sigmoid activation function. Adam optimizer was used with the loss as binary cross entropy. Accuracy metrics were used, and the model was compiled with the data for 5 epochs with a batch size of 32. Accuracy and loss for each epoch were plotted.

III. RESULTS

Fig 1 shows that, out of 3.39 million deaths, CVD was leading as an underlying cause for 930,384 (27.4%) deaths, while respiratory diseases were an underlying cause of mortality for 270,834 (7.9%) deaths. Out of 930,384 deaths due to CVD, 174,190 (18.7%) patients are suffering from respiratory diseases. Fig 2 shows the deaths due to different diseases from CVD as an underlying cause of death and different diseases from respiratory diseases as one of the multiple conditions. For different respiratory diseases, chronic lower respiratory diseases lead to more deaths. Among patients suffering from chronic lower respiratory diseases, 36,186(50.17%) deaths are due to the ischaemic heart diseases, 11,621(16.11%) deaths are due to hypertensive diseases, 6007(8.3%) deaths are due to cerebrovascular diseases, and 5199(7.2%) deaths are due to heart failure.

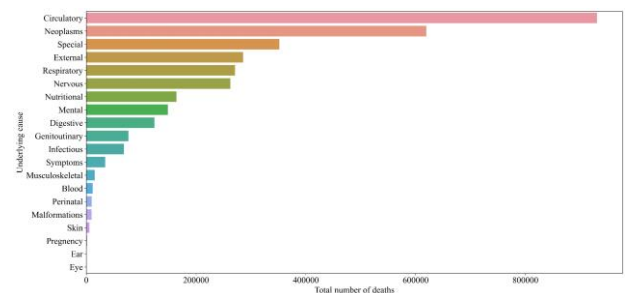


Fig. 1. The number of deaths associated with different disease categories.

Fig 3 is the correlation matrix for the features like sex, age, cardiovascular disease as one of the multiple conditions, symptoms of R00-R99 as per ICD 10 2016 format, and death due to cardiovascular disease as the underlying cause for the deaths of patients suffering from different respiratory diseases. Compared to other features presence of any cardiovascular complications is more

correlated with deaths due to an underlying cause of cardiovascular disease among patients with respiratory as one of the multiple conditions with a Pearson correlation coefficient of 0.61.

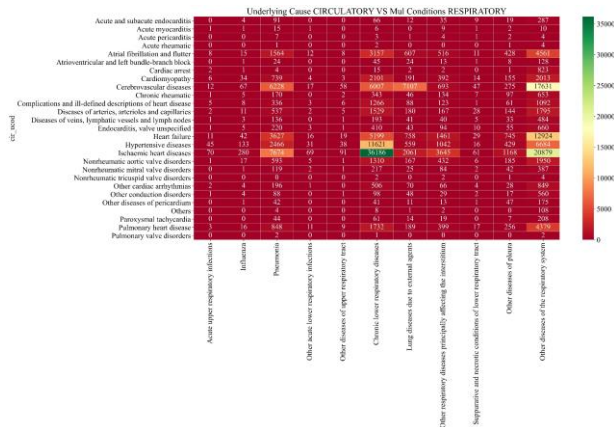


Fig. 2. Circulatory diseases as an underlying cause of death, and respiratory diseases as multiple conditions



Fig. 3. Visualization of different features with the help of heatmap

The results for the ANN model were described using the confusion matrix in Table 1. An accuracy of 76.84% was scored for the ANN model with a precision and recall of 0.68 and 0.99. The F1 score is 0.81. Fig 4 shows the improvement in accuracy; Fig 5 shows the decrease in loss with each training epoch.

TABLE I. CONFUSION MATRIX FOR ANN MODEL

	Positive	Negative
Predicted true (+)	18703	16135
Predicted false (-)	1	34837

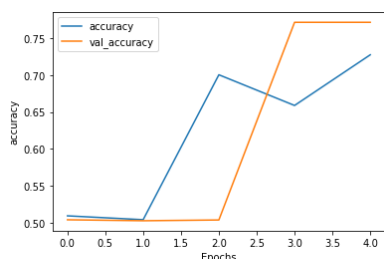


Fig. 4. Accuracy of the developed ANN model for the prediction of mortality

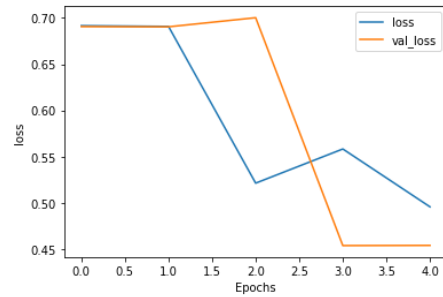


Fig. 5. Loss of the developed ANN model for the prediction of mortality

IV. DISCUSSION

In the study, data of 930,384 deaths in US mortality data of 2020 was used, and there are 174,190 (18.7%) deaths of CVD as an underlying cause of death and contains respiratory diseases as one of its multiple conditions. Accuracy for the ANN model was 50% at the initial stages of model training, 76.84%, and binary cross entropy loss decreased from 0.7 to 0.46 at the end of the 5th epoch. The study was consistent with the results of a study by Davidson et al., which stated that the incidence of acute respiratory diseases was elevated with an increased risk of CVD [4].

V. CONCLUSION

In this study, an artificial neural network model is built to predict the possibility of death due to cardiovascular disease with given respiratory conditions. Primary analysis shows that cardiovascular disease was an underlying cause for approximately 16.8% of the patients suffering from respiratory diseases. Accordingly, treatment can be adjusted to the patients, and maybe the proportion of deaths can be avoided. Further studies are required to find the exact symptoms and reasons for the increased risk of death due to cardiovascular diseases with the presence of respiratory diseases.

VI. REFERENCES

- [1] Chandrika, L., & Madhavi, K. (2021). A Hybrid Framework for Heart Disease Prediction Using Machine Learning Algorithms. E3S Web of Conferences, 309, 01043.
- [2] Mancini, D., & Gibson, G. T. (2021). Impact of Pneumonia in Heart Failure Patients. Journal of the American College of Cardiology, 77(16), 1974–1976.
- [3] Carr, G. E., Yuen, T. C., McConville, J. F., Kress, J. P., VandenHoek, T. L., Hall, J. B., & Edelson, D. P. (2012). Early Cardiac Arrest in Patients Hospitalized with Pneumonia: A Report From the American Heart Association’s Get With the Guidelines-Resuscitation Program. Chest, 141(6), 1528–1536.
- [4] Davidson, J. A., Banerjee, A., Smeeth, L., McDonald, H. I., Grint, D., Herrett, E., Forbes, H., Pebody, R., & Warren-Gash, C. (2021). Risk of acute respiratory infection and acute cardiovascular events following acute respiratory infection among adults with increased cardiovascular risk in England between 2008 and 2018: a retrospective, population-based cohort study. The Lancet Digital Health, 3(12), e773–e783.
- [5] Ahmad FB, Cisewski JA, Miniño A, Anderson RN. Provisional Mortality Data — United States, 2020. MMWR Morb Mortal Wkly Rep 2021; 70:519–522.